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(54) Title: FOOD PROCESSING IN OXYGEN-FREE ENVIRONMENT

(57) Abstract

Processing of plant seeds for foods, food ingredients and edible oils such that the end products do not have undesirable flavors or taste. The prior art methods for effective elimination or reduction of off-flavors that develop in foods, such as proteins and oils, are not very compatible with the preparation of their highly functional or desirable forms because they require conditions that cause denaturing of the foods. A method is disclosed which permits food processing with minimum denaturing while preventing development of off-flavors. The key element of the method comprises disintegrating seeds and then further processing the resulting mass sufficiently to inactivate lipoxygenase enzyme, such as by heating, in an oxygen-free environment. The disclosed applications include processing of legumes, nuts and other protein and oil bearing seeds into bland products like protein concentrates, protein isolates and edible oils. When applied to the processing of soybeans into artificial milk, the method produced high yield of soymilk which had no characteristic beany off-flavor, throat catching sensation or chalk-like mouth feel.

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FOOD PROCESSING IN OXYGEN-FREE ENVIRONMENT

FIELD OF THE INVENTION

This invention concerns the processing of plant seeds for foods, food ingredients and edible oils which have no undesirable flavor or taste. More specifically, 5 this invention relates to the method of preparing foods and beverages and extracting oils without off-flavors from soybeans and other legumes.

BACKGROUND OF THE INVENTION

10 To be generally acceptable the foods, which definition here will include food ingredients and edible oils, need not only be nutritious, versatile and economical, but also be attractive in color, aroma, taste and texture. Plant protein preparations mainly 15 from legumes and nuts, like soybeans, have unacceptable off-flavors which score heavily against their positive properties and limit their use.

Lipoxygenase enzyme has been recognized as the major cause of off-flavors in most vegetable proteins 20 sources including soybeans, peas and peanuts. Polyunsaturated fatty acids are oxidized through the catalytic action of lipoxygenase to initially produce hydroperoxides and finally yielding off-flavor causing agents like aldehydes, ketones, alcohols, furans, alpha-ketols and hydroxyacids.

25 Lipoxygenase is distributed throughout the cotyledons in legumes and many other seeds, but the enzyme is inactive because of its limited contact with oxygen and the substrate which are immobile due to the plants cell structure. Breaking of cell structure during the size reduction operation causes the oxidation to proceed. The control of off-flavors, therefore, requires inactivation of lipoxygenase enzyme.

30 Since lipoxygenase is heat sensitive, its inactivation is most commonly accomplished by thermal processing. At temperatures above 60°C. the half-lives of the various lipoxygenase enzymes rapidly decrease with increasing temperature. However, heat treatment

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also reduces the nitrogen solubility index and protein dispersibility index. The currently available methods for the effective elimination or reduction of off-flavors in plant proteins are not very compatible with
5 the preparation of their highly functional forms because they require conditions that cause denaturing of the proteins. Also, the removal of off-flavors in edible oils not only makes the oil refining process complex but also causes oil degradation. A method is needed to
10 solve these problems in a natural and simple way.

DESCRIPTION OF THE PRIOR ART

Many methods for the processing of legumes and other protein and oil bearing seeds have been proposed which alleviate the off-flavor problems in the end food products; examples are Canadian Patents: 396108 issued to E.C. Winkler and H. Goller on January 16, 1933; 457603 issued to R.A. Wait on November 9, 1938; 675029 issued to T.W.M. Paulsen on November 26, 1963; 677452 issued to R.J. Moshy on January 7, 1964; 819072 issued
15 to K. Fujita et al, on July 29, 1969; 920869 issued to J.R. Wagner on February 13, 1973; 1004531 issued to A.I. Nelson et al, on February 1, 1977; 1083879 issued to D.S. Hsieh et al, on August 19, 1980; and 1091081 issued
20 to T. Wakana et al, on December 9, 1980.

25 The flavor problems in soybean proteins have been reviewed by J.E. Kinsella and S. Damodaran in a book "The Analysis and Control of Less Desirable Flavors in Foods and Beverages" edited by G. Charalambous and published by Academic Press in 1980. F.D. Gunstone and
30 F.A. Norris in their book "Lipids in Foods: Chemistry, Biochemistry and Technology" published by Pergamon Press in 1983, have discussed the off-flavor problems in edible oils and methods for solving them. The prior art methods either try to inactivate the enzymes, such as
35 lipoxygenase, involved in producing off-flavors, prior to seed desizing and deforming operations, or remove off-flavors as much as possible after they have devel-

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oped. Both the approaches tend to degrade the end product nutritionally, functionally or otherwise. For example, low or no beany flavor soymilks prepared with prior art processes give chalk-like mouth feel due to
5 undesolved fine particles in the milks remaining even after intense high pressure homogenization. The problem generally results from the heat treatment of soybeans to inactivate lipoxygenase enzyme prior to or during the disintegration of soybeans in aqueous media. Such
10 heat treatment adversely effects the protein dispersibility index, which in turn adversely effects the soymilk yield.

The method of the present invention eliminates the off-flavor problem without adversely effecting the
15 quality or yield of the end product.

SUMMARY OF THE INVENTION

One objective of this invention is to provide a method of processing legumes and other seeds into foods having no off-flavor or undesirable taste but
20 without adversely effecting nutritional quality and functionality of the end food products. Another objective is to apply the invention method to producing soymilk with high yield and nutritional quality but without beany off-flavors and chalky mouth-feel. The
25 present invention has established that off-flavors can be prevented from developing if size reduction and additional processing, until lipoxygenase enzyme is inactivated, is carried out in an oxygen-free environment.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The present invention concerns processing of legumes and the like protein and oil-rich seeds with minimal denaturing to obtain end food products without undesirable flavors. The process comprises disintegration and deforming of the seeds, such as by grinding,
35 milling and flaking, and further processing of the seeds up to and including the stage at which at least one of

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the seed member essential for reactions producing volatiles in off-flavors, such as lipoxygenase enzyme and lipids, is either inactivated or removed, in an environment deprived of most free oxygen, the latter being 5 also an essential member in the said reaction. Since lipoxygenase catalyses the oxidation of lipids to produce off-flavor causing volatiles, one effective means of controlling off-flavors will be to desize the seeds into flakes, extract the seed oil by the solvent 10 extraction process, and heat treat the oil to inactivate lypoxygenase, in oxygenless environment. The edible oil thus extracted will be free from most off-flavors. Also, lipoxygenase in the deoiled seed flakes cannot be active since there are hardly any lipids left 15 in the said flakes, especially on the surface where oxygen from air contacts said flakes. Thus, foods made from the said flakes with prior art methods will have little or no off-flavors. However, for best results it may be desirable to process said flakes up to and 20 including the stage of cooking in oxygen-free environment.

Since flavor threshold may vary from below 0.1 ppm to above 100 ppm depending on the volatile causing an off-flavor and the substrate it is in, what is oxygen-free environment for one volatile and substrate combination 25 may not be true for another such combination. However, as a rule of thumb, total oxygen presence in the substrate and the environment said substrate sits in should not exceed the flavor threshold of the off-flavor desired to be controlled.

30 One of the more common use of this invention is expected in processing soybeans to extract oil and to prepare artificial milk, protein concentrates, protein isolates and the like, which are free from the characteristic soybean off-flavors and throat catching 35 sensation.

In the following, the term aqueous medium will be used for drinkable water as well as for dilute aqueous

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solution of acid, alkali or salt, while the term
vacuum will be used for pressures low enough to effect
boiling of the aqueous medium without heating the same.
The vacuum so defined causes release of most oxygen
5 dissolved in water and replacement of residual air in
the evacuated environment by water vapors.

The following processes illustrate the application
of the invention to soybeans processing:

1. One embodiment of the method comprises soaking
10 soybeans in an aqueous medium, rinsing the swelled soy-
beans, putting said soybeans and an aqueous medium in
a container, creating vacuum in said container, dis-
integrating said soybeans in said container, isolating
the said container from the device used to create
15 vacuum, heating the resulting slurry in said container
sufficiently to inactivate lipoxygenase enzyme and
trypsin inhibitor, and removing undesolved solids from
the cooked slurry to obtain soybean milk having good
taste and mouth-feel but without off-flavors and
20 throat catching sensation. Trypsin inhibitors are
heat sensitive substance in soybeans which inhibit
growth in growing animals and can cause pancreas en-
largement and must be adequately inactivated in an
edible product. Since soybeans are disintegrated at
25 room temperatures, which results in high protein
solubility in aqueous media, the process yields soy-
bean milk which is remarkably close to dairy milk in
mouth-feel.

2. Another embodiment of the method comprises
30 soaking soybeans in an aqueous medium, rinsing the
swelled soybeans, putting the said soybeans with an
aqueous medium, to which a deoxygenating agent like
sodium sulfite may have been added, in a closed con-
tainer with a small vent tube at the top, filling it
35 with said aqueous medium such that no air bubble is
trapped in the container and thereby establishing an
oxygenless-environment, cooking the resulting slurry

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in said container to inactivate lipoxygenase enzyme and trypsin inhibitor, and straining the cooked slurry to obtain soybean milk having good taste and mouth feel and acceptable flavor.

5 3. Another embodiment of the method comprises processing soybeans as in Embodiment 1 excepting flushing the vacuum with nitrogen gas.

10 4. Another embodiment of the method comprises processing soybeans as in Embodiment 3, excepting that the soaking of soybeans is also done in a container evacuated and flushed with nitrogen gas.

15 5. Another embodiment of the method comprises splitting and flaking dehulled soybeans, extracting oil from the soybean flakes by the solvent extraction process, flash desolventizing said flakes, heating the extracted oil sufficiently to inactivate lipoxygenase enzyme, and further processing the deoiled flakes to obtain various protein foods up to and including the stage of cooking, in vacuum or an inert gas environment.
20 The resulting end products are free from undesirable flavors or taste.

25 6. Yet another embodiment of the invention method comprises splitting and flaking dehulled soybeans, extracting oil from the soybean flakes by the solvent extraction process, flash desolventizing said flakes, and heating the extracted oil sufficiently to inactivate lipoxygenase enzyme, in vacuum or an inert gas environment. The deoiled soybean flakes are exposed to air and kept under atmospheric conditions in the usual way until
30 further processed. Because of the absence of lipids on soybean flake cells exposed to air, lipoxygenase remains inactive as in whole soybeans. Depending on the residual oil in said soybean flakes and the off-flavor level acceptable in the end products, it may or may not be
35 necessary to process said flakes to make artificial milk, protein concentrate, protein isolates, or the like, in oxygen-free environment.

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This invention is further illustrated by the following examples:

EXAMPLE 1.

75 g of whole soybeans were soaked in tap water at
5 room temperature for ten hours. The swelled soybeans
were rinsed twice with water and put with 500 ml water
in the so called one quart stainless steel container of
a Warring Commercial Blender. The container was
appropriately modified to stand high vacuum even when in
10 blending operation. A vacuum good enough to effect
boiling of water at room temperature was created in the
container using a vacuum pump capable of pumping down
to 25 micrometre Hg pressure; water boils at 17 mm Hg
pressure at 20°C. The water was allowed to boil for a
15 few minutes to effect water degassing and to replace
residual air in the container with water vapors. The
container was then isolated from the vacuum pump so that
accessive foaming may not occur when the soybeans are
disintegrated. The blender was run for 30 seconds and
20 the container was put in a boiling water bath for 20
minutes to inactivate lipoxygenase enzyme. The container
was then opened to atmosphere and the soybean slurry
transferred to a pressure cooker and the slurry cooked
for a few minutes at 15 p.s.i. pressure to inactivate
25 trypsin inhibitor. Finally, the soymilk was extracted
by straining the slurry through a cloth and mechanically
squeezing the fibrous residue. About 600 ml soymilk was
obtained that had no off-flavor or bad taste.

EXAMPLE 2.

30 150 g of whole soybeans were soaked in tap water
at room temperature for ten hours. The swelled soybeans
were rinsed twice with water and put in the container of
Example 1. The container was filled with water to the
top and closed with a custom made air tight transparent
35 lid provided with a vent tube of small diameter. It was
made sure that there were no water bubbles entrapped in
the container. The blender was run for about one minute

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to disintegrate soybeans. The container was then put in a boiling water bath for 30 minutes to inactivate lipoxygenase enzyme. The container was opened and the slurry transferred to a pressure cooker and the slurry cooked
5 for a few minutes at 15 p.s.i. pressure to inactivate trypsin inhibitor. Finally, soymilk was extracted by straining the slurry through a cloth and mechanically squeezing the fibrous residue. Soymilk was similar to that of Example 1 excepting that a very low beany flavor
10 was detectable upon refrigeration.

EXAMPLE 3.

Example 1 was repeated excepting that 500 ml of 0.1% sodium bicarbonate solution was used in place of water when placing soybean in the container. The soymilk
15 obtained had no off-flavor or bad taste but had slightly more color than that of Example 1.

EXAMPLE 4.

Example 2 was repeated excepting that about 100 miligrams of sodium sulfite was added to the contents
20 of the container to deoxygenate water. The soymilk thus obtained was not significantly better than that of Example 2.

EXAMPLE 5.

Example 1 was repeated with vacuum flushed with
25 nitrogen gas at about atmospheric pressure. The soymilk obtained was similar to that in Example 1.

All the soymilks of Example 1 to 5 gave mouth-feel similar to that of dairy milk. Soymilk flavor or taste was easily possible to enhance or change by adding sugar,
30 common salt, flavors, colors and the like.

Since many apparently widely different embodiments of this invention could be made without departing from the scope and spirit thereof, it is intended that all matter contained in the above description be interpreted
35 as being illustrative only and not limiting.

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The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1 1. A method for preparing protein foods without the
2 characteristic off-flavors or bitter taste from legumes
3 and other protein containing seeds comprising:

4 i) size reduction of said seeds in an oxygen-free en-
5 vironment that may be partially or fully an aqueous
6 medium comprising of drinkable water or dilute aqueous
7 solution of an acid, alkali or salt; and,
8 ii) further processing the resulting mass sufficiently
9 to inactivate lipoxygenase enzyme, such as by heating,
10 in said environment.

1 2. A method of extracting edible oil and preparing
2 foods without the characteristic off-flavors or bitter
3 taste from legumes and other seeds comprising:

4 i) flaking of said seeds in an oxygen-free environment;
5 ii) desolving oils from seed flakes in an organic sol-
6 vent in said environment;

7 iii) recovering the desolved oil from said solvent in
8 said environment;

9 iv) heat treating said oil to inactivate lipoxygenase
10 enzyme in said environment;

11 v) flash desolvantizing the deoiled flakes in said en-
12 vironment; and,

13 vi) processing said flakes into artificial milk, protein
14 concentrates, protein isolates, or the like, up to and
15 including the stage of cooking in said environment.

1 3. A method as defined in Claim 2 wherein the flash
2 desolvantized flakes are exposed to air for selling,
3 moving, storage, or the like, and processing said flakes
4 into artificial milk, protein concentrates, protein
5 isolates, or the like, up to and including the stage of
6 cooking, in an oxygen-free or oxygen containing environ-
7 ment.

1 4. A method of preparing defatted flakes, meals,
2 flour and the like foods with little or no characteristic
3 off-flavors or bitter taste from legumes and other seeds

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4 comprising:

- 5 i) preparing flash desolvantized flakes as defined in
6 Claim 2 in oxygen-free or oxygen containing environment;
7 ii) optionally heating said flakes to inactivate lipoxy-
8 genase enzyme in said environment; and
9 iii) disintegrating said flakes in said environment.

INTERNATIONAL SEARCH REPORT

International Application No PCT/US86/00521

I. CLASSIFICATION OF SUBJECT MATTER (If several classification symbols apply, indicate all) ³

According to International Patent Classification (IPC) or to both National Classification and IPC
 IPC (4) : A23L 1/015, 1/20; A23J 3/00
 U.S. Cl. 426/629

II. FIELDS SEARCHED

Minimum Documentation Searched ⁴

Classification System	Classification Symbols
U.S.	426/312, 319, 629, 634, 656, 417, 430, 489, 518

Documentation Searched other than Minimum Documentation
 to the Extent that such Documents are Included in the Fields Searched ⁵

III. DOCUMENTS CONSIDERED TO BE RELEVANT ¹⁴

Category ⁶	Citation of Document, ¹⁵ with indication, where appropriate, of the relevant passages ¹⁷	Relevant to Claim No. ¹⁸
A	US, A, 2,524,991, Published 10 October 1950 Renner	1-4
X	US, A, 4,369,198, Published 18 January 1983 Uchi et al	1
X	US, A, 4,209,541, Published 24 June 1980 Clatfelter et al	1-4

- * Special categories of cited documents: ¹⁶
- "A" document defining the general state of the art which is not considered to be of particular relevance
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IV. CERTIFICATION

Date of the Actual Completion of the International Search ¹⁹

04 May 1986

Date of Mailing of this International Search Report ²⁰

09 MAY 1986

International Searching Authority ²¹

ISA/US

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